Innovative technology for phosphate removal from dewatered sludge supernatant

Frank Gnanam, *Business Manager* Virotec Global Solutions Pty Ltd
Peter Reberger, *Plant Manager* EGL Management Services Pty Ltd

ABSTRACT

Biological nutrient removal sewage treatment plants release biologically assimilated phosphorous from anaerobically digested sludge. When this sludge is dewatered, a phosphate rich supernatant is obtained. The current industry practice of diverting the supernatant to the head of the works significantly increases the phosphorous loading on the treatment process.

EGL operate the Redcliffe City Council WWTP, and use hydrated lime (Ca(OH)2) to treat phosphate via an existing lime slurry system. EGL have been looking at alternatives to the use of lime as it represents an OH&S hazard and the dosing process had become operationally inefficient and costly to maintain.

This paper reports on the work that Virotec Global Solutions have undertaken with EGL to develop a formulation to treat phosphates, achieving a removal rate of 99.84% (from 500 mg/L to 0.8 mg/L).

KEY WORDS

Dewatered sludge supernatant, phosphate, phosphorous, sewage treatment.

INTRODUCTION

The Redcliffe Waste Water Treatment Plant is located in the Redcliffe City Council suburb of Clontarf and serves a population of 50,000 persons. The WWTP is a Biological Nutrient Removal process plant, one of the first such systems built in Queensland. The WWTP is a 12.5 MLD plant and consistently meets all of its treated wastewater discharge license limits. Redcliffe City Council has contracted EGL to maintain and operate the WWTP under a long term arrangement.

Sewage treatment plants which are modified for biological nutrient removal (BNR), release biologically assimilated phosphorous from anaerobically digested sludge. When this sludge is dewatered, a phosphate rich supernatant is obtained. The current industry practice of diverting the supernatant to the head of the works *without further treatment* significantly increases the phosphorous loading to the sewage treatment plant, thereby impacting the biological phosphorous removal efficiency and reliability.

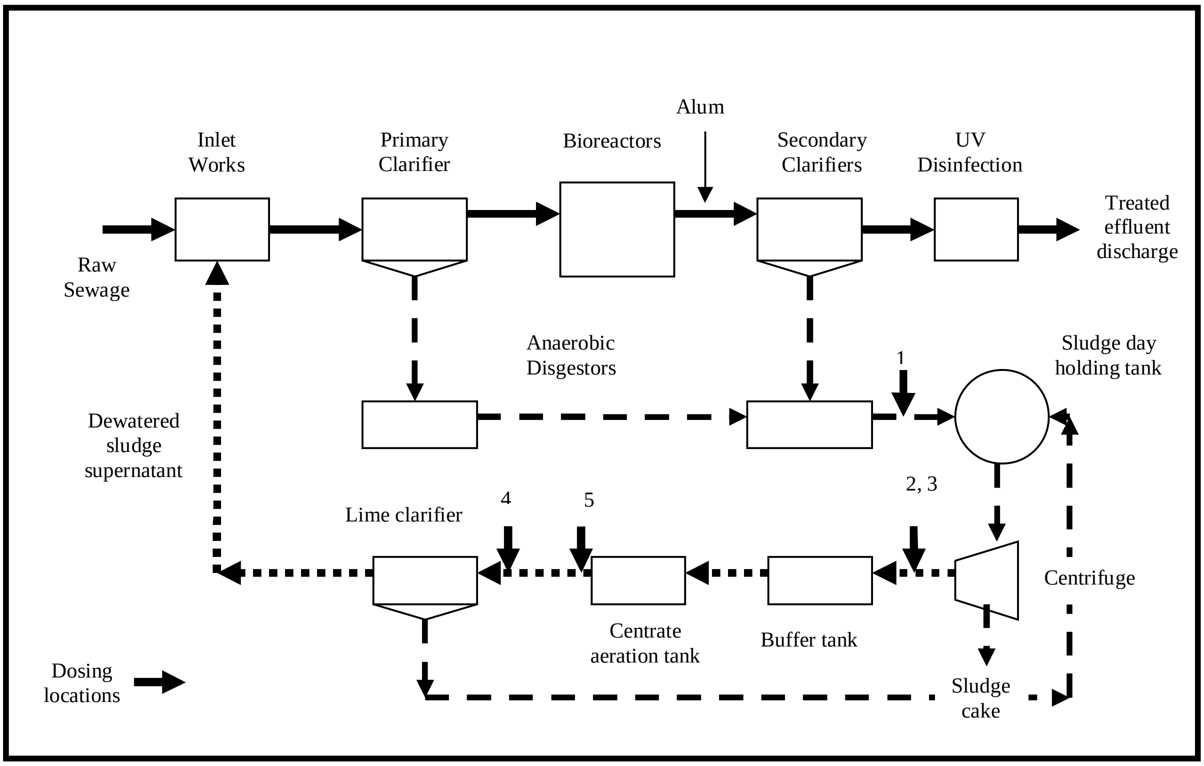
In 2003, EGL were approached about trialling a Virotec technology to remove phosphorus from the wastewater. There was scepticism about this technology but after some research into Virotec's case history[1] on Kilcoy Shire Council's sewage treatment plant, EGL decided to trial the technology.

Problems were also identified with heavy metals in digested sludge and with the usage of lime to precipitate phosphorus from the dewatered sludge supernatant or centrate. Whilst lime is acknowledged as a useable product for sewage treatment plant processes, the OH & S issues associated with lime dust and the operation and costly maintenance of a lime dosing system is seen as a problem for every treatment plant that uses it.

DISCUSSION

The WWTP process layout is depicted in Figure 1 below. EGL prepared lime slurry on site to treat phosphate in dewatered sludge supernatant. The lime slurry is dosed into the dewatered sludge supernatant line (location 5, Fig. 1). The average phosphorous loading in the raw sewage influent was 65 kg/day and the dewatered sludge supernatant contributed an additional 26 kg /day approximately. If left untreated, the increased phosphorous loading created an imbalance in the overall kinetics of the BNR system.

Although lime is known to be effective in reducing phosphate concentrations in the dewatered sludge supernatant, EGL had been looking at alternative technologies, as the use of lime represented an Occupational Health and Safety hazard for its personnel. Coupled with the difficulty of maintenance of the lime make-up and batching facility, the associated dosing system had become operationally inefficient.



<u>Figure 1</u> ***Process Layout of the Redcliffe WWTP***

Digested sludge from the anaerobic digesters is transferred to a sludge day-holding tank from which it is fed into dewatering machines (centrifuges). The dewatered supernatant or centrate is collected and pumped to a buffer tank, which has a capacity of 120,000 litres. It is then transferred to an aeration tank, which has a capacity of 50,000 litres. From the aeration tank, the supernatant is gravity fed to a lime clarifier, which has a capacity of 15,000 litres. Lime slurry was dosed into the stilling well of this clarifier and the treated supernatant returned to the primary clarifier system by gravity. The sludge from the lime clarifier was pumped out, at regular intervals, and transported off-site for disposal at a landfill site.

Virotec Global Solutions, a Queensland based environmental technology company provides a technology which includes: (a) the supply of reagents (that are capable of reducing phosphate in sewage effluents) blended according to a specific recipe and dosed at a specific location within the wastewater treatment process flow, and (b) the design and supply of a mixing and dosing plant.

ViroSewage™ Technology uses a patented 2 stage set of reagents to affect phosphate removal, where a ViroSewage™ reagent A (a geochemically modified bauxite refinery solid) acts to remove soluble P and provides templates for Fe-oxyhydroxides (induced by the addition of ferric chloride or sulphates – reagent B) to precipitate over the removed P to mineralize the P to the solids; these solids are then separated from the liquids ([2] Drew et al., 2003).

One of the constraints placed on the initial field trials by EGL was that Virotec was required to work with the existing infrastructure with no new capital assets to be sourced. The dewatered sludge supernatant had initial phosphate concentrations ranging from 430 mg/L to 500 mg/L. After applying ViroSewage™ Technology the final treated effluent phosphate concentrations were as low as 0.8 mg/L, achieving a removal rate of 99.84%.

Virotec tested several dosing application points within the system (locations 1 to 5; Fig 1). Initially, Virotec applied its base ViroSewage™ Technology to various different locations in the sludge line to establish the optimum location and the best treatment (locations 1-4; Fig.1). A complete review of the treatment recipe was undertaken in a series of bench top experiments in the laboratory while the plant was being treated with the base ViroSewage™ reagents at location 4 (Fig 1).

The laboratory tests concluded that the polymer used by EGL to coagulate the solids and assist in the dewatering process, was interfering with the P removal and causing rising sludge in the lime clarifier, where the solids were being separated. The resulting modification to the ViroSewage™ reagents in the batch tests, were able to remove phosphate (PO4) in the presence of the polymer without forming a rising sludge. Phosphate concentrations of 0.3 to 1.5 mg/L were achieved in the lab tests. One of the additional benefits of this new formulation observed in the laboratory testing was that suspended solids dropped from >500 to <100mg/L, COD fell from >450 to <200 mg/L, and ammonia also fell from >400 to <300 mg/L.

Based on these laboratory results, it was decided to switch the trial to the new formulation (reagent C) with a change to the dosing point so that there was at least a 4 minute contact time between the ViroSewage™ reagent C with the centrate. The ViroSewage™ reagent C was dosed at location 5 (Fig 1), whereas previously the reagent A was added at location 4. Although no reagent B is used with the new formulation, it may be used as a further polishing step. Data for the trial preceding the switch in reagents and following the switch are presented graphically in Figure 2.

It can be seen from the graph that prior to the switch which occurred around 13/07/05, phosphate concentrations in the treated centrate were rarely below 20mg/L. Subsequently, the treatment appears to have settled with consistent results below 5 mg/L. Incoming phosphate concentrations in raw sewage were around 5 mg/L to 10 mg/L. As a consequence, the trials were declared a success and the trial was converted into a full scale commercial contract, with emphasis on continual improvement to the treatment. Generally, the treated phosphate levels ranged from 0.8 to 2 mg/L consistently.

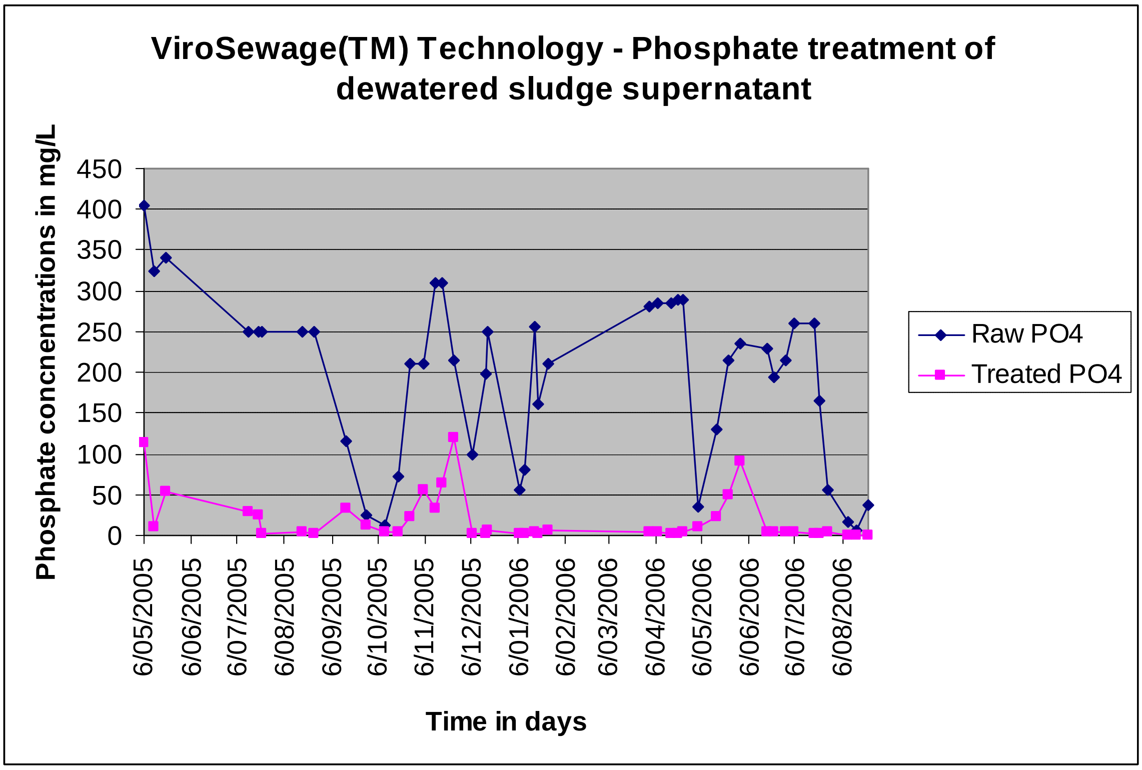


Figure 2 ***Results of treatment for 15 months***

Fig 3 depicts detailed results from June 2006 to August 2006, where the treated phosphate levels were consistently below 1 mg/L.

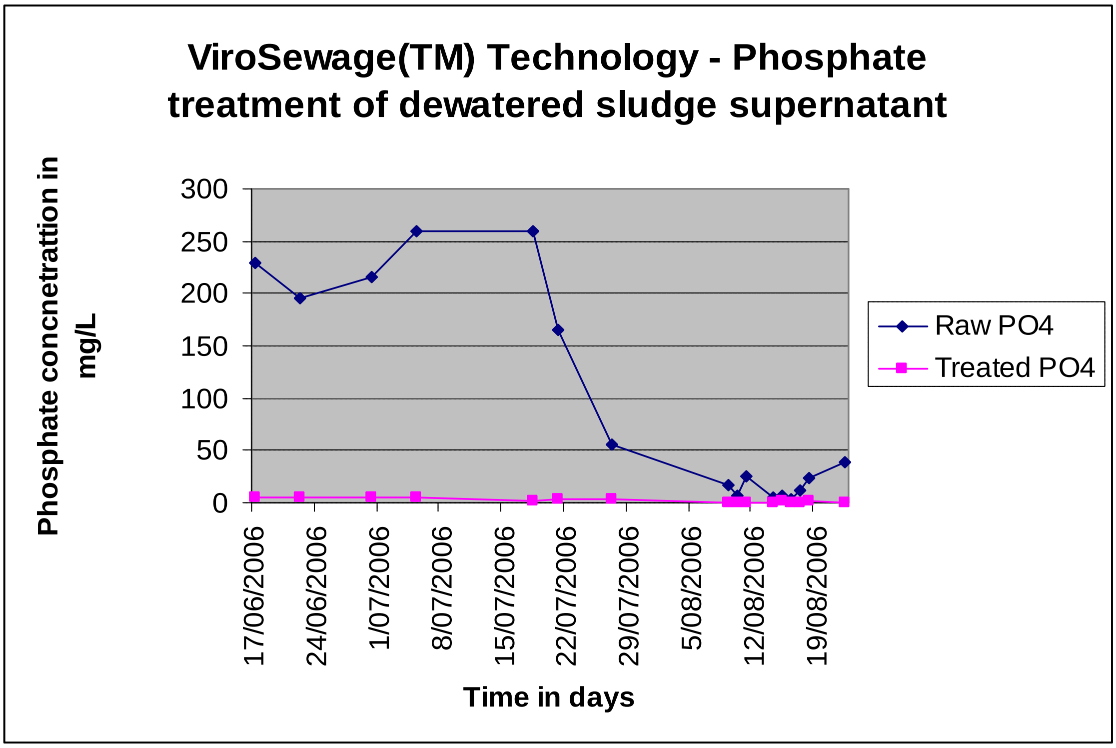


Figure 3 ***June 2006 to August 2006 results***

It was also discovered that by returning the settled sludge from the lime clarifier to the sludge day holding tank, the ViroSewage™ reagent C was still reacting and treating the phosphate from fresh digested sludge feedstock to the centrifuges. Tests on samples taken directly from the centrate line immediately after the centrifuge showed phosphate concentrations of 60 mg/L, where previously it used to be anything from 250 mg/L to 500 mg/L.

After reviewing the above process the dry sludge cake was tested for moisture content and compared to past results. The result was a 24% dry cake, with sludge solids content varying between 2.9% to 3.5%. Feed rate to the centrifuge was around 18m3/h at that time, a rate typical for this site. Past results of dry cake was around 18 – 20%.

It was noted that polymer consumption had also decreased dramatically, down to 4.7 kg of polymer per dry tonne of sludge, from a previous high of about 12 kg of polymer per dry tonne.

Early in 2006 EGL recommissioned the aeration tank (diffused air system) and set up a dosing point directly into the aeration tank. With a capacity of 50,000 litres, ample detention time and mixing was assured. The extra tank capacity has given greater flexibility with flow rates and better phosphorus removal.

CONCLUSION

EGL reviewed the whole technology, regarding its viability, with a view to setting up a permanent dosing installation. They documented savings with polymer, alum, dewatering, sludge dry weights, sludge cartage and disposal costs. EGL's savings in their overall sludge handling and management process are summarised in Table 1 below. All these cumulative savings enabled EGL to absorb other chemical price increases, namely in alum costs (increased 26%), and polymer costs (increased 5%).

Table 1 ***Savings generated as a consequence of adopting ViroSewage™ Technology***

Cost Factors	Pre-ViroSewage™ Technology 2004 / 05	With ViroSewage™ Technology 2005 / 06	Savings
Annual lime usage and maintenance of lime batching facility	$31,200	Nil	$31,200
Annual Alum usage	$27,408	$28,152	($744)
Annual Polymer usage	$84,350	$59,604	$24,746
Sludge removal from site	$195,378	$165,139	$30,239
ViroSewage™ Technology	Nil	$28,800	(28,800)
Total savings	$338,336	$281,695	$56,641
Percentage savings			16.74%

ViroSewage™ Technology has demonstrated that in addition to the improved phosphate removal from the dewatered sludge supernatant, the technology has not affected the BNR process adversely. On the contrary, the WWTP continues to consistently meet all of its license discharge conditions, including meeting phosphate discharge targets. There is improved pH balance in the plant process and additional flow-on benefits have been reported by EGL as follows:-

1. The replacement of lime for phosphate removal with ViroSewage™ Technology has resulted in the elimination of an OH&S issue. Operationally, there has been savings in cost of product as well as maintenance expenditure.
2. The monthly expense of cleaning out the lime clarifier, handling and transport of lime sludge has been eliminated.
3. A reduction in the amount of alum being dosed pre-secondary clarifier;
4. A reduction in polymer use for sludge conditioning.
5. The quality of dewatered sludge has improved and higher dry solids content has been achieved. This has resulted in more solids being transported off-site (less water being carted).

ACKNOWLEDGEMENTS

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REFERENCES

1. Virotec Global Solutions Pty Ltd. (2003) *Case Study: Kilcoy Sewage Treatment Plant*. www.virotec.com.

2. Drew, D.M., Ducksbury, A.N., and Josey, D. (2003) *Process for treatment of waste water, separation, deodorisation and reuse of biosolids,* International Patent Application.